

[10537/319]

## RUN-IN COATING FOR GAS TURBINES AND METHOD FOR PRODUCING SAME

The present invention relates to a run-in coating for gas turbines according to the definition of the species in Claim 1. In addition, the present invention relates to a method for producing a run-in coating according to the definition of the species in Claim 9.

Gas turbines, such as, for instance, aircraft engines, include, as a rule, a plurality of rotating rotor blades as well as a plurality of stationary stator blades, the rotor blades rotating together with a rotor, and the rotor blades as well as the stator blades being enclosed by a stationary housing of the gas turbine. It is meaningful to optimize all components and subsystems when it comes to improving the performance of an aircraft engine. Among those are also the so-called sealing systems in aircraft engines. In aircraft engines, a particular problem is keeping a minimum gap between the rotating rotor blades and the stationary housing of a high pressure compressor. For, the highest absolute temperatures and temperature gradients occur in high pressure compressors, and this makes maintaining the gap of the rotating rotor blades from the stationary housing of the compressor more difficult. Among other things, this is also because in the case of compressor rotor blades shrouds, as are used in turbines, are omitted.

As was mentioned before, rotor blades in a compressor have no shrouds available to them. Therefore, ends, or rather tips of the rotating rotor blades are exposed to a direct frictional contact with the housing in the case of so-called brushing against the stationary housing. Such a brushing of the tips of the rotor blades against the housing is brought about by the setting of a minimum radial gap by manufacturing

tolerances. Since, on account of the frictional contact of the tips of the rotating rotor blades to the housing, material is eroded, it is possible for an undesired gap enlargement to set in over the entire circumference of housing and rotor. In order to avoid this, it is known from the related art that one may fortify the ends or tips of the rotating rotor blades with a hard coating or with abrasive particles.

Another possibility of avoiding the wear at the tips of the rotating rotor blades and of assuring an optimized sealing between the ends or tips of the rotating rotor blades and the stationary housing, is to coat the housing with a so-called run-in coating. In material removal on a run-in coating, the radial gap is not enlarged over the entire circumference, but only in the shape of a sickle, as a rule. This avoids a drop in performance of the engine. Housings having a run-in coating are known from the related art.

Using this as a starting point, the present invention is based on the object of creating a new type of run-in coating for gas turbines.

This object is attained in that the run-in coating mentioned at the outset is refined by the features of the characterizing part of Claim 1.

The run-in coating according to the present invention for gas turbines is used for sealing a radial gap between a stationary housing of the gas turbine and rotating rotor blades of the same. The run-in coating is applied onto the housing. According to the present invention, the run-in coating is produced from an intermetallic titanium-aluminum material.

According to one advantageous embodiment of the present invention, the run-in coating made of the titanium-aluminum

material has a stepped or graded material composition and/or porosity. Particularly advantageous is an embodiment in which the run-in coating is developed to be less porous, at an inner region lying directly adjacent to the housing and at an outer region lying directly adjacent to the rotor blades, than between these two regions. Therefore, the run-in coating is developed to be denser and harder at the inner region lying directly adjacent to the housing, and at the outer region lying directly adjacent to the rotor blades. The inner region lying directly adjacent to the housing is used, in this context, to promote adhesion; the outer region lying directly adjacent to the rotor blades is used to make available erosion protection.

The method according to the present invention for producing a run-in coating is specified in independent Claim 9.

Preferred further developments of the present invention are revealed by the dependent claims and the following description.

Exemplary embodiments of the present invention are explained in detail in light of the drawing, without being limited to it. The figure in the drawing shows:

Fig. 1: a greatly schematic representation of a rotor blade of a gas turbine together with a housing of the gas turbine and having a run-in coating situated on the housing.

In a greatly schematic manner, Fig. 1 shows a rotating rotor blade 10 of a gas turbine, which rotates with respect to a stationary housing 11 in the direction of arrow 12. A run-in coating is situated on housing 11. Run-in coating 13 is used to seal a radial gap between a tip or an end 14 of rotating

rotor blade 10 and stationary housing 11. The demands made on such a run-in coating are very complex. Thus, for instance, the run-in coating has to have optimized abrasive characteristics, that is, good chip formation and removability of the abraded material must be ensured. Furthermore, there must not be any material transfer to rotating rotor blade 10. Run-in coating 13 must also have low frictional resistance. Moreover, run-in coating 13 must not ignite when rotating rotor blade 10 brushes against it. As additional demands made on run-in coating 13 we cite erosion resistance, temperature stability, resistance to heat change, corrosion resistance with respect to lubricants and sea water, for example. Fig. 1 makes clear that, conditioned by centrifugal forces occurring during the operation of the gas turbine and the heating of the gas turbine, ends 14 of rotor blades 10 come into contact with run-in coating 13, and thus abraded material 15 is set free. This pulverized abraded material 15 must not cause any damage on rotating rotor blades 10.

Housing 11, shown schematically in Fig. 1, is the housing of a high pressure compressor, according to the preferred exemplary embodiment. Such housings of high pressure compressors are increasingly made up of intermetallic materials of the type TiAl or Ti<sub>3</sub>Al. Such intermetallic titanium-aluminum materials have a low density and are superior to the usual titanium alloys, with respect to their temperature stability.

Now, it is within the meaning of the present invention to apply a run-in coating 13, also made of an intermetallic titanium-aluminum material, onto a housing 11 that is made of an intermetallic titanium-aluminum material. We should point out that such a run-in coating, made of an intermetallic titanium-aluminum material, may also be applied to a housing that is made of a usual titanium alloy.

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Within the meaning of the present invention, run-in coating 13 made of the intermetallic titanium-aluminum material has a stepped material composition and/or porosity, that is, one which changes in a stepwise manner, or it has a graded material composition and/or porosity, that is, one which changes in an almost stepless manner. The properties of run-in coating 13 may be adapted to the specific demands made on it by the selective setting of the material composition and/or the porosity.

According to one preferred refinement of run-in coating 13 according to the present invention, it has a low porosity in an inner region 16 that is directly adjacent to housing 11, and also in an outer region 17 that is directly adjacent to rotor blades 10. Between this inner region 16 and this outer region 17, on the other hand, the porosity of the run-in coating is increased. Inner region 16 of run-in coating 13, which is directly adjacent to housing 11, is used to promote adhesion between run-in coating 13 and housing 11. Outer region 17 of run-in coating 13, which is directly adjacent to rotor blades 10, forms an erosion protection. However, depending on the demands made on run-in coating 13, this erosion protection may also be omitted.

The ratio of titanium to aluminum within run-in coating 13, that is made of the intermetallic titanium-aluminum material, is preferably approximately constant. This means that, in this case, exclusively the porosity of run-in coating 13 is made in stepped or graded fashion for influencing the hardness and rigidity.

It is also imaginable, however, that the ratio of titanium to aluminum within run-in coating 13 might be made in stepped or graded fashion. In this case, more titanium is preferably contained in the inner region 16 in run-in coating 13 that is

directly adjacent to housing 11 than in outer region 17 of run-in coating 13. This means that in outer region 17 of run-in coating 13 more aluminum is contained than in inner region 16 of same, which borders on housing 11.

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The use of a run-in coating made of an intermetallic titanium-aluminum material on a housing which is also made of an intermetallic titanium-aluminum material, or of a titanium alloy, has the advantage that the fastening of the run-in coating to the housing takes place via chemical bonding, and thereby the fastening is more secure and durable than is the case with run-in coatings according to the related art. Furthermore, between a run-in coating and a housing that have the same basic composition, no high temperature diffusion between the housing and the run-in coating will take place. Moreover, there will be no thermal expansion problems, since the housing and the run-in coating uniformly expand or contract in response to temperature increase or temperature decrease. It is because of this that a uniform maintaining of the gap and a higher service life of the run-in coating can be achieved. A run-in coating developed according to the present invention also has a high resistance to oxidation, as well as a high stability to temperature change. The blade tips of the rotating rotor blades are submitted to only a minimal blade tip abrasion.

It is within the meaning of the present invention to produce run-in coating 13 according to the present invention in such a way that run-in coating 13 is made available in the form of a slip material, and is applied to housing 11 with the aid of slip technology. Such a slip material based on an intermetallic titanium-aluminum material is preferably applied onto housing 11 by brushing, dipping or spraying. This preferably takes place in several steps or rather layers, so that a multi-layer run-in coating 13 develops.

In order to set the desired porosity in the respective layers, additive substances are intercalated in the slip material. After the application of the slip material, hardening or  
5 baking of the slip material takes place onto housing 11. During baking, the additives added to the slip material evaporate, and because of this the pores inside run-in coating 13 remain behind. On account of the number and type of the added additive substances, one may set the number and the size  
10 of the pores.

Alternatively, run-in coating 13 may also be produced by applying it with the aid of a directed vapor jet. Such a directed vapor jet may be generated with the aid of a PVD  
15 method (physical vapor deposition) or a CVD method (chemical vapor deposition). Shortly before the impinging of the directed vapor jet that is based on an intermetallic titanium-aluminum material, at least one additive is fed in or incorporated into the vapor jet, these additives being  
20 vaporized again during the subsequent baking, and in the process leaving behind pores within the layer or each layer of run-in coating 13.

In the case of the additives for setting the porosity, so-called microballs, that is, tiny filled or hollow plastic  
25 beads, polystyrene beads or other materials may be involved which vaporize during the baking of the intermetallic titanium-aluminum material.

30 The run-in coating according to the present invention may be produced especially favorably both with the aid of slip technique and PVD or CVD technique.